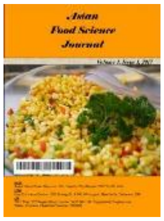

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Chemical and Sensory Evaluation of Cereal-Based Complementary Foods Supplemented with Soybean and Monkey Kola

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Authors' contributions

This work was carried out in collaboration between all authors. The first author DBKK is the major supervisor who designed the study and wrote the protocol. The second author AGOO is the M.Sc. student who wrote the first draft of the manuscript, managed the literature searches and the analyses of the study. The third author MOA is the collaborative Supervisor who supported and guided the student. All authors read and approved the final manuscript.

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ABSTRACT

Different blends of cereal-based complementary foods were formulated from millet/maize, soybean and yellow monkey kola flours. Seven blends were formulated from maize (*Zea mays*) flour, partially defatted soybean (*Glycine max*) flour and monkey kola (*Cola parchycarpa*) flour while seven other blends were formulated from millet (*Pennisetum americanium*) flour, partially defatted soybean flour and monkey kola flour. All the blends were evaluated for proximate and sensory attributes with a branded complementary food as control (cerelac maize). Samples that conformed to set standards in the proximate parameters and had the highest sensory scores were further evaluated for amino acid profile. Results showed that moisture content of the millet and maize-based blends ranged from 5.15 to 6.73% and 5.15 to 8.29%, respectively. They all fell within the codex requirement of <10%. Ash content for all the blends were less than 3% while fat content of both millet and maize-based

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blends increased with increase in substitution level. Protein content of samples E1, F1, G1, F2 and G2 exceeded 15% acceptable limit. Crude fibre content of all samples conformed to <5% set by many organisations. All test samples were in line with codex standard of not less than 58% in terms of carbohydrate content. Energy content ranged from 387.87 to 402.73 kcal/100 g and 379.34 to 399.43 kcal/100 g for millet and maize-based blends, respectively. The results of the sensory evaluation of the products showed that the commercial product scored higher than the experimental blends and that the millet-based blend did not differ significantly (p>0.05) from the maize-based blend in terms of overall acceptability. The amino acid profile result showed that all essential amino acids were present in the test samples, in amounts exceeding the minimum requirement for complementary foods.

Keywords: Complementary foods; cereal; soybean; monkey kola; proximate composition; amino acid profile; sensory evaluation.

1. INTRODUCTION

Proper nutrition is a key for the growth and development of a child from infancy into adulthood. Naturally, breast milk is the best form of nutrition for babies but from the age of 4-6months, semi-solid foods are introduced to the child, to complement breast milk. In West Africa, the first complementary foods are usually prepared from maize (*Zea mays*), millet (*Permisetum americanum*), guinea corn (*Sorghum species*) or their blends. These meals are starchy being mostly carbohydrate in nature. They are viscous which makes it difficult for the babies to eat enough quantity of food that would meet their nutrient and energy requirements. Aside being starchy and bulky, these foods are limited in protein and micronutrients. Maize and millet protein, for instance, contains moderate amount of sulphur containing amino acids but are limited in essential amino acid like lysine and tryptophan. These traditional complementary foods have been associated with protein energy malnutrition (PEM), poor growth and development recorded among children of developing countries, a disease condition like kwashiorkor and marasmus has been linked to frequent use of maize pap (ogi or koko) and millet gruels as weaning foods [1]. In Nigeria and indeed most developing countries, there have been several attempts to reduce the problem of protein and mineral deficiency in sole cereal gruels. Various organisations and individuals have strongly maintained that food fortification remains a long lasting solution to malnutrition problems in West Africa ([2]; ICN [3]; Kennedy et al. [4]). The Nigerian Federal Ministry of Health (FMOH) recommends that a protein source and fruits/vegetables be blended into staple starchy roots, tubers or cereals in formulating complementary foods for infant and young children [5]. This is to improve the protein and micronutrient densities of traditional complementary foods.

Cola parchycarpa S. Schum, commonly called monkey kola, refers to a group of lower cola species of the same family as the West Africa kola nut (*C. nitida and C. acuminate*), they belong to the family *Malvaceae* and sub-family *Sterculioideae*. They are consumed in Southern Nigeria and Cameroun. In Nigeria, the ogonis call it aya, the Igbos call it “achicha” while the Efiks call it “ndiyan”. There are three common species of monkey kola: *Cola pachycarpa*, *Cola lepidota* and *Cola lateritia*, two of these three varieties, *Cola lepidota* (white specie) and *Cola pachycarpa* (yellow specie), were identified botanically in the department of Forestry, Michael Opara University of Agriculture Umudike, Abia State, Nigeria [6]. Ene-Obong et al. [7] while evaluating the nutrient and phytochemical composition of two varieties of monkey kola (*Cola parchycarpa* and *Cola lapidota*), reported that yellow monkey kola is rich in β-carotene, a pro vitamin A carotenoid, rich in calcium, iron, zinc and magnesium. This means that monkey kola is beneficial in boosting body immunity, preventing anaemia in children, help in the formation of strong bones and teeth and also prevent vitamin A deficiency disorder among infants and young children.

Monkey kola has been classified among neglected and underutilised species of tropical rich plants in West Africa. Ogbu and Umeokechukwu [8] in their research on the aspect of fruit biology of three edible monkey kola species noted that these neglected and underutilised species, despite their potential health and nutritious benefits, are going extinct due to lack of sustained exploitation and Institutional supports.

The aim of this work, therefore, is to develop complementary foods using a blend of millet or maize, soybean and monkey kola (*Cola parchycarpa*) and to evaluate the proximate properties, sensory characteristics and amino acid profile of the developed blends.

2. MATERIALS AND METHODS

Millet (*Pennisetum glaucum*), yellow maize (*Zea mays*), soybean (*Glycine max*) and yellow monkey kola (*Cola parchycarpa)* fruits were purchased from mile 3 market, Diobu, Port Harcourt, Rivers State, Nigeria. Cerelac was purchased from Next Time supermarket, Port Harcourt.

2.1 Methods of Processing

Millet, maize and soybean grains were each sorted and cleaned to remove stones, sand, husks and grains of other cereals. After cleaning, 5kg of each of the cleaned seeds were soaked for two (2) days and the water changed daily. After two days, the seeds were washed in clean water, boiled separately for 45 min each and dried separately in an oven temperature of 65^{o}C for 10h. The dried seeds were separately milled using an attrition mill, to obtain the millet, maize and soybean flours. The flours were passed through 150 micron particle size sieve to obtain the individual flours that were used for the analysis. The soybean flour was further mixed with food grade hexane and allowed to stand for 1h, after which the solution was poured into a muslin cloth and pressed using a screw press. The residue from the press was transferred into an oven tray and dried for 6h at a temperature of 70^{o}C to obtain the partially defatted soybean flour that was used for the experiment. The flour of monkey kola (*Cola parchycarpa*) was produced by slightly modifying Okudu et al. [6] method. Yellow monkey kola fruit (15 kg) was de-husked, the fruit pulp washed with clean water and cut into two to remove the seed, the inner membrane of the pulp was scrapped using a plastic teaspoon and then the clean pulp was grated directly into a clean oven tray and dried for 10 h at a temperature of 65^{o}C. The dried pulp was then milled using an attrition mill and sieved with 150 micron particle size sieve to obtain the monkey kola flour that was used for the analysis.

2.2 Formulation Ratio for the Complementary Blends

Seven samples of millet, soybean and monkey kola flours were formulated to consist of varying percentage of each ingredient, supplementing the millet flour with different proportions (0, 10, 15, 20 and 25%) of soybean and monkey kola with Nestle cerelac maize, a commercial complementary product as control. The formulations were then mixed properly and sequentially using a Philip mixer (Type HR 1500A rotary mixer) to obtain a homogenous blend. The blends were stored separately in air tight glass bottles and preserve in a deep freezer for analysis. Seven other samples of maize, soybean and monkey kola flours were formulated to consist of varying percentage of each ingredient, supplementing the maize flour with different proportions (0,10, 15, 20 and 25%) of soybean and monkey kola flours. The blends were then mixed properly using a Philip mixer (Type HR 1500A rotary mixer) to obtain a homogenous blend. The blends were singly put in air tight glass bottles and stored in a deep freezer for analysis using Nestle cerelac maize as the control sample. The formulation for both the millet-based blends and the maize-based blends is shown in Table 1.

Table 1. Formulation of millet-based and maize-based complementary blends

Samples	Millet or maize (%)	Soybean (%)	*Cola Parchycharpa* (%)
A	100	0	0
B	90	0	10
C	90	10	0
D	80	10	10
E	70	15	15
F	60	20	20
G	50	25	25

2.3 Proximate Analysis of the Blends

The standard method of AOAC [9] was used to determine the proximate composition of the blends. For moisture content, hot air oven (Thermo Scientific-UT 6200, Germany) was used to dry 2 g sample weight to a constant weight, at 105°C and the moisture content was calculated. The fat content was determined using the Soxhlet extraction method. Petroleum ether was used in a Soxhlet apparatus (Gerhardt Soxtherm SE-416, Germany) to extract fat from a known weight of sample. The extract was dried in an oven at a temperature of 105°C for 1h, cooled in a desiccator and the weight of fat calculated. Crude protein was determined using the micro-Kjeldahl method and each sample's percentage protein calculated by multiplying their nitrogen value by the factor of 6.25. Two gram (2g) sample weight was ignited in a muffle furnace (Carbolite AAF-11/18, UK) for 5h at 550°C and the ash content determined as a percentage of the sample weight. Crude fibre was calculated after 2 g of the sample was defatted, hydrolysed and filtered; the residue was washed free from acid and incinerated in a muffle furnace. The total carbohydrate content was estimated by difference while the energy values in Kcal/100g were determined by standard calculations (Atwater factor), where factors of 4, 4 and 9 were used for protein, carbohydrate and fat, respectively.

All the parameters were analysed in duplicates and results expressed as mg/100 g (dry matter basis).

2.4 Sensory Evaluation of the Blends

Sensory evaluation of all the formulations were carried out using 20 semi-trained panelist which consist of nursing mothers, staff and students who are familiar with complementary foods from the Department of Food Science and Technology, Rivers State University, Port Harcourt, Nigeria. The evaluations were conducted in two sections using a 9 - point hedonic scale ranging from 1 to 9 which represent dislike extremely and like extremely, respectively. In the first session, 50g each of the millet-based formulated blend and 50g each of the maize-based blends were constituted separately by adding 200 ml of hot distilled water and stirred properly. These samples were evaluated for colour, flavour, taste, consistency, mouth-feel and overall acceptance. The most acceptable formulation was taken from each of the maize-based and millet-based combinations, reconstituted as in the first section and evaluated in the second section using commercially available Nestle Cerelac maize as control.

2.5 Amino Acid Profile of the Blends

The amino acid profiles of the samples were determined according to Benitez [10] methods. Four gram (4 g) of the sample was weighed, dried to constant weight, defatted, hydrolysed by acid hydrolysis, evaporated in a rotary evaporator and loaded into the Applied Biosystems PTH Amino Acid Analyzer (120A, Germany). An integrator attached to the Analyzer calculates the peak area proportional to the concentration of each of the amino acids. Tryptophan was hydrolysed using 4.2M NaOH according to Del Mar Yust et al. [11] and determined as in other amino acids.

2.6 Statistical Analysis

Data obtained were subjected to a one way Analysis of Variance (ANOVA), the Duncan Multiple Range Test (DMRT) was used to separate means at $p<0.05$ level using SPSS package version 21.0.

3. RESULTS AND DISCUSSION

3.1 Proximate Composition of the Formulated Complementary Blends

The proximate compositions of millet-based blends and maize-based complementary foods are shown in Tables 2 and 3. The moisture content of the formulated millet-based blends ranged from 5.15 to 6.73% while that of the maize-based blends ranged from 5.15 to 8.29%. Similar value (8.33%) was reported by Ikujenlola et al. [12] for moisture content of complementary foods produced from a blend of malted maize and fluted pumpkin seed. This level of moisture content of the blends was low enough to prevent microbial growth and enhance the keeping quality of the products. According to Codex International Standards, the moisture content of such food products should not be more than 10% [13].

The ash content of the millet-based ranged from 0.71 to 2.43% while maize-based ranged from

0.58 to 2.18%. It was also observed that the ash content of both the maize-based blend and millet-based blend increased significantly with the increase in the addition of monkey kola. The same trend was observed in other complementary foods formulated using fruits/vegetable [14,15]. Results obtained in this study are related to those reported for ash content of complementary food formulated from millet, soybeans and crayfish [16]. Comparing the millet-based with the maize-based blends however, showed that the millet-based blends were higher than that of the maize-based blends in ash content. This could be attributed to the fact that millet is higher in mineral than maize [17]. Results of the ash content of samples A1 and A2 which had 100% cereal were significantly lower than all other samples. However, the commercial product was significantly (p>0.05) higher than other samples.

The fat content of the formulated products were higher in samples G1 and G2, with the highest substitution of soybean and monkey kola flours (6.44% and 7.05%, respectively), but lower than the commercial product. Samples C1 and C2 with no inclusion of soybean had the lowest fat levels of 3.69% and 3.76%, respectively. Whereas samples B1 and B2 which had no monkey kola but soybean was high in fat content with the values of 6.43% and 6.63%, respectively. Fat is important in the body especially for children, it increases energy density of the diet, provides essential fatty acids, speeds up absorption of fat soluble vitamins, improves palatability and prevents undue weight gain in infants [15]. FAO/WHO [18] recommended that the calorie derived from fat be raised to a level of 20% of total energy while Michaelsen et al. [19] stated that 30 to 40% of energy from fat is recommended.

Protein content varied significantly in all the products. In the millet-based products, it ranged from 8.37 to 16.91% while protein content of the maize-based products was within the range of 6.34 to 16.78%. Also, the protein content of samples B1 and B2 which had 10% substitution with soybeans and 0% monkey kola was significantly higher (p<0.05) than the values obtained from samples C1 and C2 with 0% soybean. The protein levels of blends E1, F1, G1, F2 and G2 conform to the range recommended by FAO/WHO/CAC [20] and these samples were higher than the commercial product in terms of protein content. Anigo *et al*. [21] obtained lower values of protein (6.37±0.23 to 7.88±0.28g/100g) from complementary food gruels formulated from malted cereals, soybeans and groundnut. Protein is important for growth and replacement of tissues and for lean body mass. Lack or insufficient protein leads to kwashiorkor in children and the protein contents in the blends with 20 and 25% substitution levels with soybean meets the FAO/WHO/CAC [20] recommendation of not lower than 15% (dry matter).

The results for the crude fibre in both millet-based blends which ranged from 0.18 to 0.41% and maize-based blends (0.09 to 2.46%) agreed with the recommended limits. They are lower than the crude fibre content of the control sample (4.5%). Maximum value of 5% of crude fibre for infants and young children has been set by the Codex [22,13]. Fibre improves bowel movement, enhances digestion and prevents constipation. Carbohydrates content of sample A1 with 100% millet was 82.03% while that of sample A2 with 100% maize blend was 83.92%. Lower values were recorded in the blends with higher level of substitution of soybean and monkey kola. The major constituent of cereal is carbohydrate and a reduction in the carbohydrate level as a result of substitution with soybean and monkey kola resulted in lower carbohydrate values of the substituted blends. The carbohydrate values observed in this study are comparable to the range of 67.5 to 68.75% and 68.7 to 72.7% reported by Iombor et al. [16] and Faki [23], respectively. They are however, higher than the carbohydrate value of the control sample (65 g/100 g dry matter basis).

Energy value of the formulated blends was slightly lower than that of the control (404.03 kcal/100 g). The range of the millet-based blends was from 387.87 to 402.73 kcal/100 g while the maize-based blend ranged from 384.25 to 394.38 kcal/100 g. This is just slightly lower than Codex [13] and FAO/WHO/UNU [24] guidelines. CAC recommends that 100 grams of food should provide not less than 400 kcal of energy. Notwithstanding, sugar could be added to the products and this will increase the energy content to meet the recommended standard.

Table 2. Proximate composition of millet-based complementary blend

Samples	Moisture (%)	Ash (%)	Fat (%)	Protein (%)	Fibre (%)	CHO (%)	Energy (kcal/100 g)
A1	6.14^{b}±0.08	0.71^{e}±0.03	3.81^{d}±0.18	9.22^{e}±0.09	0.19^{d}±0.02	79.94^{a}±0.18	390.91^{bc}±0.55
B1	6.35^{ab}±0.14	0.83^{de}±0.09	6.43^{b}±0.57	17.38^{b}±0.62	0.18^{d}±0.03	68.84^{c}±1.16	402.73^{a}±2.91
C1	6.44^{ab}±0.02	0.97^{d}±0.04	3.69^{d}±0.41	8.75^{e}±0.53	0.24^{d}±0.03	79.92^{a}±0.98	387.87^{c}±1.85
D1	6.73^{a}±0.07	1.77^{c}±0.18	5.51^{c}±0.25	13.15^{d}±0.59	0.25^{d}±0.02	72.61^{b}±0.75	392.57^{b}±1.58
E1	6.72^{a}±0.11	1.81^{c}±0.04	5.58^{c}±0.40	16.80^{b}±0.30	0.32^{c}±0.02	68.78^{c}±0.65	392.52^{b}±2.18
F1	6.34^{ab}±0.11	2.28^{b}±0.14	5.59^{bc}±0.10	17.42^{b}±0.62	0.22^{d}±0.02	67.80^{c}±0.99	394.41^{b}±0.61
G1	6.58^{ab}±0.51	2.43^{a}±0.08	6.35^{b}±.16	19.92^{a}±.042	0.41^{b}±.01	64.31^{d}±1.02	394.07^{b}±0.98
C3	5.15^{c}±0.07	2.98^{a}±0.04	9.63^{a}±0.10	14.93^{c}±0.08	2.90^{a}±0.06	64.42^{d}±0.21	404.03^{a}±0.38
*Codex standards	<10	<3		15.00	<5	58.00	400.00

Values with the same superscript along a column are not significantly different(p<0.05).

Keys: *Ml:S:Mk = Millet/Soybean/Monkey kola, A1 = (100:0:0), B1 = (90:10:0:), C1 = (90:0:10), D1 = (80:10:10), E1 = (70:15:15), F1 = (60:20:20), G1 = (50:25:25), C3 (Control) = Nestle Cerelac maize, *Codex [22].*

Table 3. Proximate composition of maize-based complementary blends (Dry Weight Basis)

Samples	Moisture (%)	Ash (%)	Fat (%)	Protein (%)	Fibre (%)	Carbohydrate (%)	Energy (Kcal/100 g)
A2	7.51^{b}±0.59	0.57^{f}±0.01	3.45^{e}±0.35	6.34^{f}±0.19	0.17^{de}±0.01	81.98^{a}±0.46	384.25^{e}±2.28
B2	8.29^{a}±0.29	0.74^{ef}±0.07	6.63^{bc}±0.33	12.72^{d}±0.24	0.84^{c}±0.15	73.66^{c}±0.22	379.34^{f}±0.47
C2	7.58^{b}±0.19	0.99^{e}±0.15	3.76^{e}±0.04	6.28^{f}±0.22	2.46^{b}±0.04	76.07^{b}±0.20	389.01^{d}±1.32
D2	7.65^{ab}±0.22	1.40^{d}±0.13	5.94^{d}±0.44	11.05^{e}±0.31	0.15^{de}±0.03	73.83^{c}±0.25	392.94^{c}±1.73
E2	7.19b^{c}±0.19	1.61^{cd}±0.02	6.48^{cd}±0.01	12.87^{d}±0.12	0.11^{e}±0.01	71.76^{d}±0.35	396.78^{b}±0.87
F2	6.56^{c}±0.31	1.74^{c}±0.63	6.45^{cd}±0.20	15.47^{b}±0.38	0.28^{d}±0.02	69.51^{e}±0.35	397.97^{b}±1.90
G2	6.69^{c}±0.14	2.18^{b}±0.28	7.05^{b}±0.27	16.86^{a}±0.11	0.09^{e}±0.02	67.14^{f}±0.82	399.43^{b}±0.44
C3	5.15^{d}±0.07	2.98^{a}±0.04	9.63^{a}±0.10	14.92^{c}±0.07	2.90^{a}±0.06	64.42^{g}±0.21	404.03^{a}±0.38
***Codex standard**	**<10.00**	**<3.00**		**15.00**	**<5.00**	**58.00**	**400.00**

Values with the same superscript along a column are not significantly different (p<0.05).

Keys: *Mz:S:Mk = Maize/Soybean/Monkey kola, A2 = (100:0:0), B2 = (90:10:0), C2 = (90:0:10), D2 = (80:10:10), E2 = (70:15:15), F2 = (60:20:20), G2 = (50:25:25), C3 = (Control) Nestle Cerelac maize, *Codex [22].*

3.2 Sensory Evaluation of the Formulated Blends

The sensory scores of the experimental blends is presented in Table 4 and it reveals that significant (p<0.05) differences existed in the organoleptic properties evaluated. Sample A1 with 100% millet had the least score for colour while sample G1 with the highest level of substitution had the highest score for colour. Millets generally have dull colour, addition of soybean and monkey kola hence, improved the colour of samples E1, F1 and G1. The flavour mean scores for the millet-based blends were higher in samples F1 and G1 with the values of 7.40 and 7.65, respectively. Similarly, these two samples recorded better taste, consistency, mouth feel and overall acceptability. Sample F1 was generally most preferred with the value of 7.50. With respect to maize-based complementary blends, no significant (p>0.05) difference was observed in terms of the colour and overall acceptability of the blends. However, mean score for the overall acceptability of sample F2 was higher (7.50). In terms of flavour and taste, higher scores were recorded in samples E2, F2, and G2 which had higher level of substitution than other samples with lower substitution levels. This is an indication that substitution with soybean and monkey kola improved the flavour and taste of the product. Sample E2 had a better mouth feel but there was no significant (p>0.05) difference between it and samples F2 and G2. Samples F2 and G2 did not also differ from all other samples in terms of mouth feel.

3.3 Amino Acid Profile of the Formulated Complementary Blends

The results of the amino acid profile of the complementary blends are shown in Table 6. Leucine was highest in sample A1 (8.99 g/100 g protein) and lowest in the control (5.67 g/100 g protein). Lysine was highest in sample F2 (6.36) and lowest in sample A1 which is 100% maize (3.13 g/100 g protein) while isoleucine was highest in the control and lowest in sample A1 (7.16 and 3.08 g/100 g protein, respectively). The values obtained in the substituted blends were similar to those reported by Solomon [25] with values of 4.82, 4.00 and 4.16 for leucine, lysine and isoleucine, respectively and they conform to FAO reference values of 4.20, 2.20 and 4.20, respectively. The control sample was lower in phenylalanine than the substituted samples. All substituted samples analysed were higher than the FAO reference value of 2.80 g/100 g protein. The value for tryptophan is lower in the 100% millet and 100% maize than in all substituted samples. Report has it that Tryptophan is limited in cereals but substitution with soybean increased its value considerably. Methionine was highest in the control than in all other samples while histidine was higher in samples F2, G1 and G2 than the control sample. Finally, threonine was found to be lowest in the control sample (1.71 g/100 g protein) and highest in sample F1 (4.05 g/100 g protein).

Table 4. Sensory Scores of the Millet-Based Complementary Blends

Sample code	Colour	Flavour	Taste	Consistency	Mouthfeel	Overall acceptability
A1	$5.05^{c} \pm 2.50$	$5.90^{b} \pm 2.10$	$5.40^{c} \pm 2.19$	$6.75^{ab} \pm 1.80$	$5.20^{b} \pm 1.77$	$5.75^{c} \pm 1.94$
B1	$5.45^{bc} \pm 2.63$	$5.95^{b} \pm 2.03$	$5.20^{c} \pm 1.82$	$6.10^{b} \pm 1.80$	$5.20^{b} \pm 2.07$	$5.90^{c} \pm 1.77$
C1	$5.55^{bc} \pm 2.41$	$6.60^{ab} \pm 1.19$	$6.90^{ab} + 1.52$	$6.80^{ab} \pm 1.70$	$5.35^{ab} \pm 1.89$	$6.85^{c} \pm 1.66$
D1	$6.60^{ab} \pm 1.79$	$5.95^{b} \pm 2.04$	$6.15^{abc} \pm 2.11$	$6.70^{ab} \pm 1.78$	$7.15^{a} \pm 1.14$	$6.65^{c} \pm 1.76$
E1	$7.00^{a} \pm 1.45$	$6.55^{ab} \pm 1.67$	$6.60^{ab} \pm 1.88$	$6.60^{ab} \pm 1.67$	$6.95^{a} \pm 0.89$	$7.00^{b} \pm 1.52$
F1	$7.15^{a} \pm 1.53$	$7.40^{a} \pm 1.14$	$7.40^{a} \pm 1.43$	$7.60^{a} \pm 1.05$	$7.50^{a} \pm 1.15$	$7.50^{a} \pm 1.43$
G1	$7.65^{a} \pm 1.09$	$7.65^{a} \pm 1.31$	$7.60^{a} \pm 1.43$	$7.45^{a} \pm 1.23$	$7.50^{a} \pm 1.88$	$7.15^{a} \pm 2.08$

Values with the same superscript along a column are not significantly different (p<0.05).
Keys: A1 = (100:0:0) Millet/Soybean/Monkey kola, B1 = (90:10:0), C1 = (90:0:0),
D1 = (80:10:10), E1 = (70:15:15), F1 = (60:20:20),
G1 = (50:25:25).

Table 5. Sensory scores of the maize- based complementary blends

Samples	Colour	Flavour	Taste	Consistency	Mouthfeel	Overall acceptability
A2	$7.15^{a}\pm1.73$	$6.25^{b}\pm2.09$	$5.60^{d}\pm2.01$	$6.95^{ab}\pm1.67$	$5.85^{b}\pm2.35$	$6.45^{a}\pm2.01$
B2	$7.25^{a}\pm1.12$	$6.80^{b}\pm1.61$	$6.50^{cd}\pm1.64$	$7.05^{ab}\pm1.67$	$6.40^{b}\pm1.98$	$6.95^{a}\pm1.47$
C2	$7.40^{a}\pm0.99$	$6.25^{b}\pm2.10$	$6.10^{cd}\pm1.65$	$6.65^{bc}\pm1.73$	$6.40^{b}\pm1.43$	$6.65^{a}\pm1.35$
D2	$6.80^{a}\pm1.82$	$6.75^{ab}\pm2.05$	$6.65^{abcd}\pm1.69$	$5.10^{c}\pm2.27$	$6.25^{b}\pm2.07$	$6.70^{a}\pm1.98$
E2	$7.25^{a}\pm1.25$	$7.15^{ab}\pm1,06$	$6.80^{abc}\pm1.61$	$7.30^{a}\pm1.38$	$7.35^{a}\pm0.93$	$7.45^{a}\pm0.89$
F2	$7.65^{a}\pm1.60$	$7.55^{a}\pm1.23$	$7.25^{ab}\pm1.64$	$6.70^{ab}\pm1.63$	$7.00^{ab}\pm1.55$	$7.50^{a}\pm1.61$
G2	$6.90^{a}\pm1.80$	$7.15^{a}\pm1.63$	$7.70^{a}\pm1.38$	$5.90^{bc}\pm2.57$	$6.95^{ab}\pm1.99$	$7.25^{a}\pm1.74$

Values with the same superscript along a column are not significantly different (p<0.05).

***Keys:** A2 = (100:0:0) Maize/Soybean/Monkey kola, B2 = (90:10:0), C2 = (90:0:10), D2 = (80:10:10), E2 = (70:15:15), F2 = (60:20:20), G2 = (50:25:25).*

Table 6. Essential Amino acid profile (dry weight basis)

Amino Acid	A1 (g/100 g protein)	A2 (g/100 g protein)	F1 (g/100 g protein)	F2 (g/100 g protein)	G1 (g/100 g protein)	G2 (g/100 g protein)	C3 Control	FAO/WHO requirement (g/100 g protein)* 0.5-1yr
Leucine	$8.99^{a}\pm0.01$	$8.61^{b}\pm0.04$	$8.00^{b}\pm0.07$	$8.61^{c}\pm0.01$	$7.30^{d}\pm0.04$	$6.92^{e}\pm0.03$	$5.67^{f}\pm0.04$	6.60
Lysine	$3.13^{f}\pm0.01$	$4.03^{e}\pm0.01$	$5.65^{b}\pm0.04$	$6.36^{a}\pm0.02$	$4.83^{c}\pm0.03$	$4.35^{d}\pm0.07$	$4.41^{d}\pm0.03$	5.70
Isoleucine	$3.08^{g}\pm0.03$	$3.60^{f}\pm0.01$	$4.81^{c}\pm0.01$	$5.21^{b}\pm0.08$	$4.19^{d}\pm0.04$	$3.93^{e}\pm0.03$	$7.16^{a}\pm0.01$	3.20
Phenylalanine	$3.73^{e}\pm0.03$	$4.00^{d}\pm0.00$	$5.00^{b}\pm0.07$	$5.32^{a}\pm0.03$	$4.26^{c}\pm0.01$	$4.00^{d}\pm0.03$	$3.47^{f}\pm0.04$	
Tryptophan	$0.79^{e}\pm0.02$	$0.71^{d}\pm0.01$	$1.00^{b}\pm0.03$	$1.08^{a}\pm0.01$	$1.05^{a}\pm0.01$	$0.89^{c}\pm0.01$	$0.84^{d}\pm0.03$	0.85
Valine	$3.04^{e}\pm0.03$	$3.10^{e}\pm0.01$	$4.30^{b}\pm0.08$	$4.56^{a}\pm0.04$	$2.80^{f}\pm0.01$	$3.51^{d}\pm0.04$	$3.90^{c}\pm0.03$	4.30
Methionine	$1.18^{b}\pm0.07$	$1.02^{c}\pm0.01$	$0.85^{e}\pm0.01$	$1.00^{cd}\pm0.03$	$0.91^{de}\pm0.03$	$1.07^{c}\pm0.07$	$2.36^{a}\pm0.04$	
Histidine	$3.20^{b}\pm0.03$	$3.38^{a}\pm0.04$	$2.42^{f}\pm0.03$	$2.88^{d}\pm0.01$	$3.00^{c}\pm0.06$	$2.72^{e}\pm0.03$	$2.51^{f}\pm0.06$	2 .00
Threonine	$3.22^{d}\pm0.06$	$3.05^{e}\pm0.03$	$3.72^{b}\pm0.01$	$4.05^{a}\pm0.03$	$3.39^{c}\pm0.04$	$4.00^{a}\pm0.09$	$1.71^{f}\pm0.01$	3.10

Values with the same superscript along a column are not significantly different (p<0.05), ± mean and standard deviation of duplicate samples.

***Keys:** A1 = (100:0:0) Millet/Soybean/Monkey kola, A2 = (100:0:0), F1 = (60:20:20), F2 = (60:20:20), G1 = (50:25:25), G2 = (50:25:25), C3 = (Control) Nestle Cerelac Maize, *FAO/WHO/UNU [26] reference protein for children 0.5 to 1yr.*

4. CONCLUSION

Complementary foods were successfully formulated using a blend of cereal (millet and maize), soybean and monkey kola flours. The blends with 60% cereal, 20% soybean, 20% monkey kola and the blends with 50% cereal and 25% each for soybean and monkey kola conformed to international standards in the parameters analysed. This means that these formulated blends are suitable to improve the nutrient density of traditional complementary foods and could successfully prevent malnutrition among children of developing countries. To combat malnutrition problems, the use of plants found in local environments should be encouraged in the production of complementary foods. Sugar could also be added to this product to improve the taste and increase the energy density of the produced complementary foods. In addition, underutilised and neglected food materials found in local environments should be investigated for possible use in the production of complementary foods. Further studies on carotenoids and mineral bioavailability should equally be investigated.

COMPETING INTERESTS

Authors have declared that no competing interests exist among them.

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